

An underwater photograph showing a large amount of plastic debris, including white and yellow plastic bags, a blue rope, and other fragments, floating in clear blue water. Several fish are visible, some swimming near the debris. The scene illustrates the impact of macroplastic debris on marine life.

# Accounting for impacts of macroplastic debris in Life Cycle Assessments (LCA)

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ATLANTIS



NTNU



# Physical effects of macroplastic on marine biota

**ENTANGLEMENT**

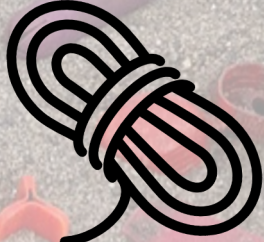
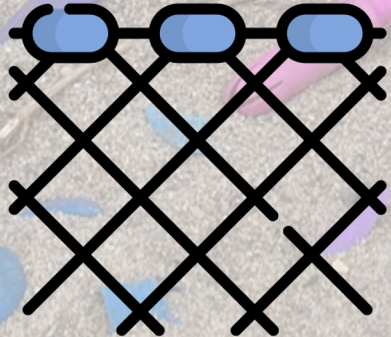
→ Effect factor developed

**INGESTION**

→ Effect factor to be developed

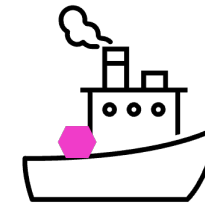
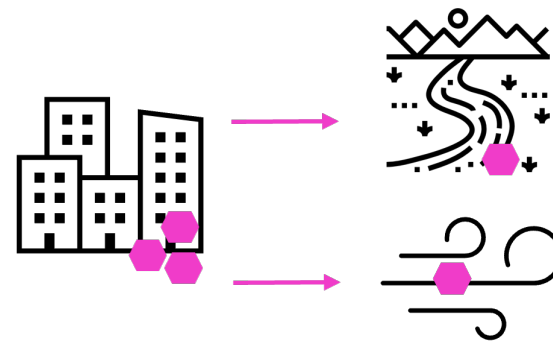
**SMOTHERING**

→ Not included



## IMPACT PATHWAY

- **Inventory and pre-fate:** emissions to the marine environment
- **Fate:** marine spatial distribution probabilities
  - Polymer-specific degradation rate
- **Effect:** potentially affected fraction of species (PAF/kg.km<sup>2</sup>)
  - Item-specific hazard potential



**Impact =**

**Emission x Fate Factor x Degradation rate x Effect Factor x Hazard potential**

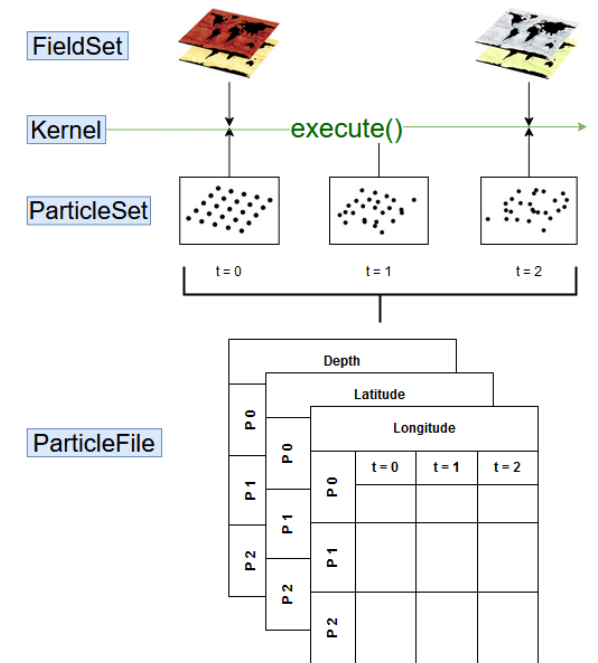
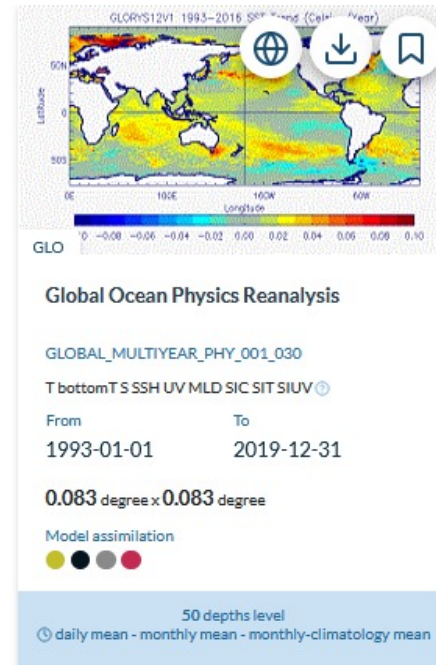
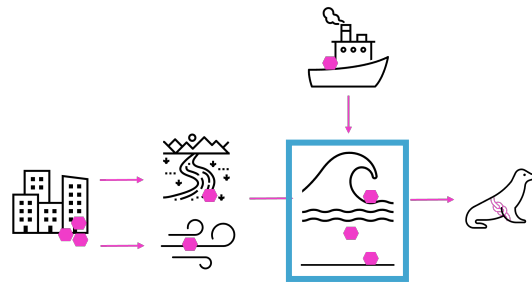
# MACROPLASTIC FATE MODEL

## Spatial distribution potential

- Country-specific
  - trajectories from coastline
  - trajectories from fishing hotspots in EEZ

## Persistence in the environment

- Polymer-specific degradation rates

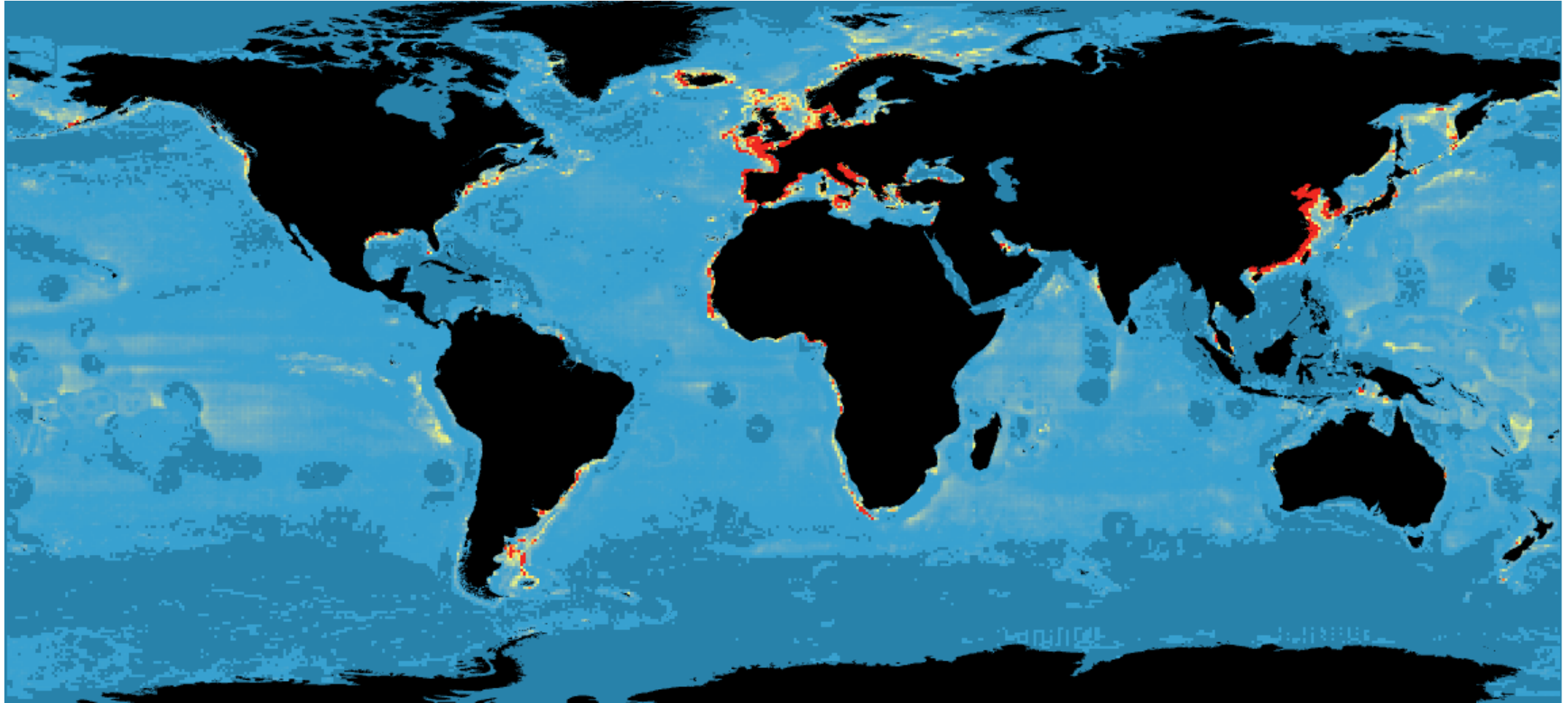


## Modelling approach

Lagrangian particle tracking simulations using *OceanParcels* with hydrodynamic data from *Copernicus Marine Service*

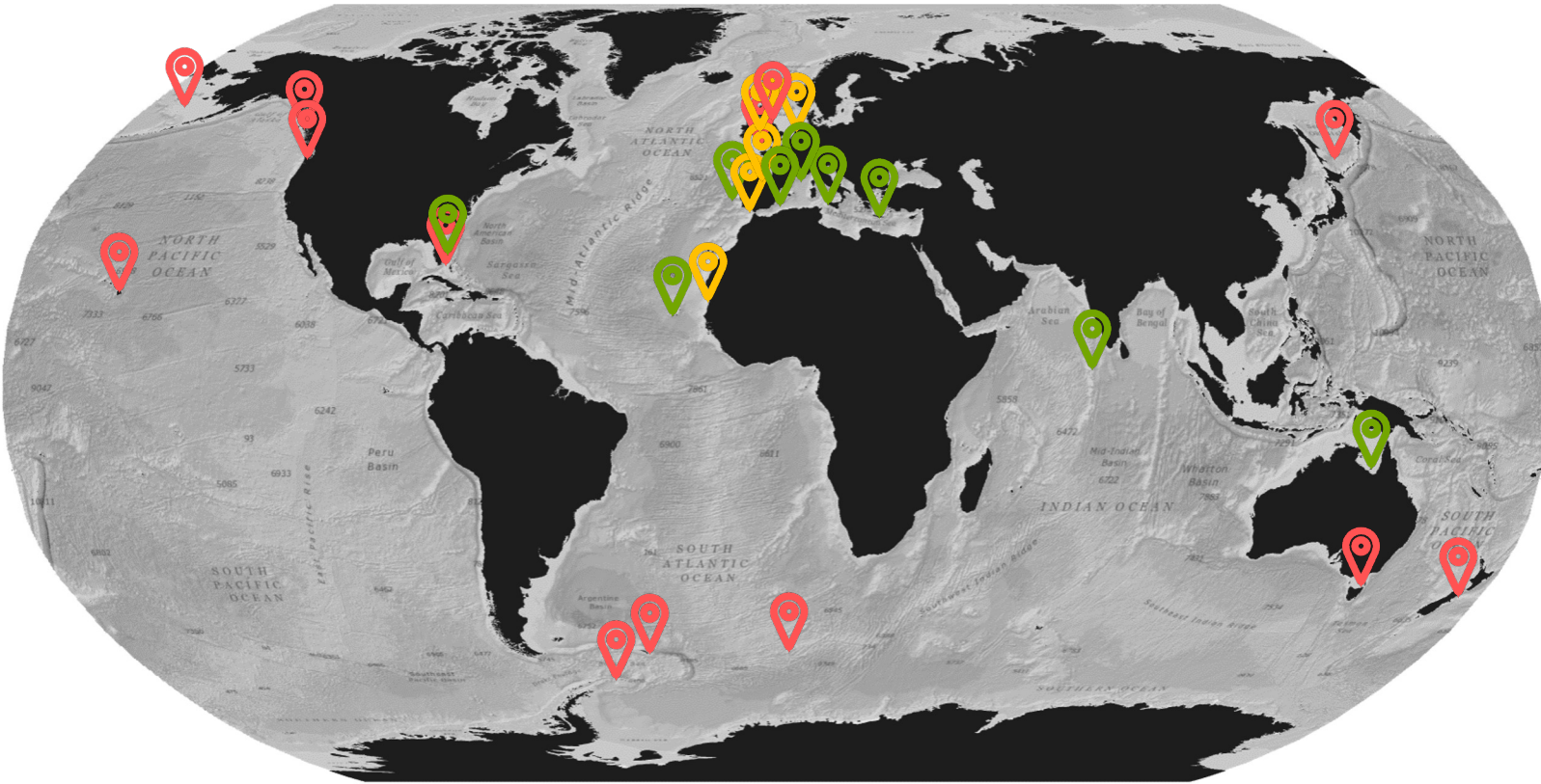
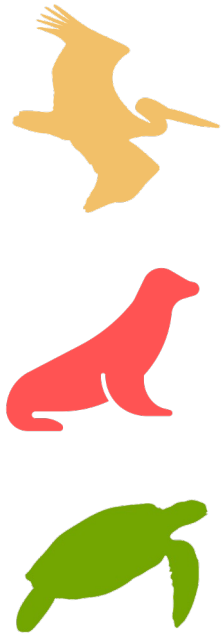


## GLOBAL FISHING EFFORT (H KM<sup>-2</sup>) 2012-2020



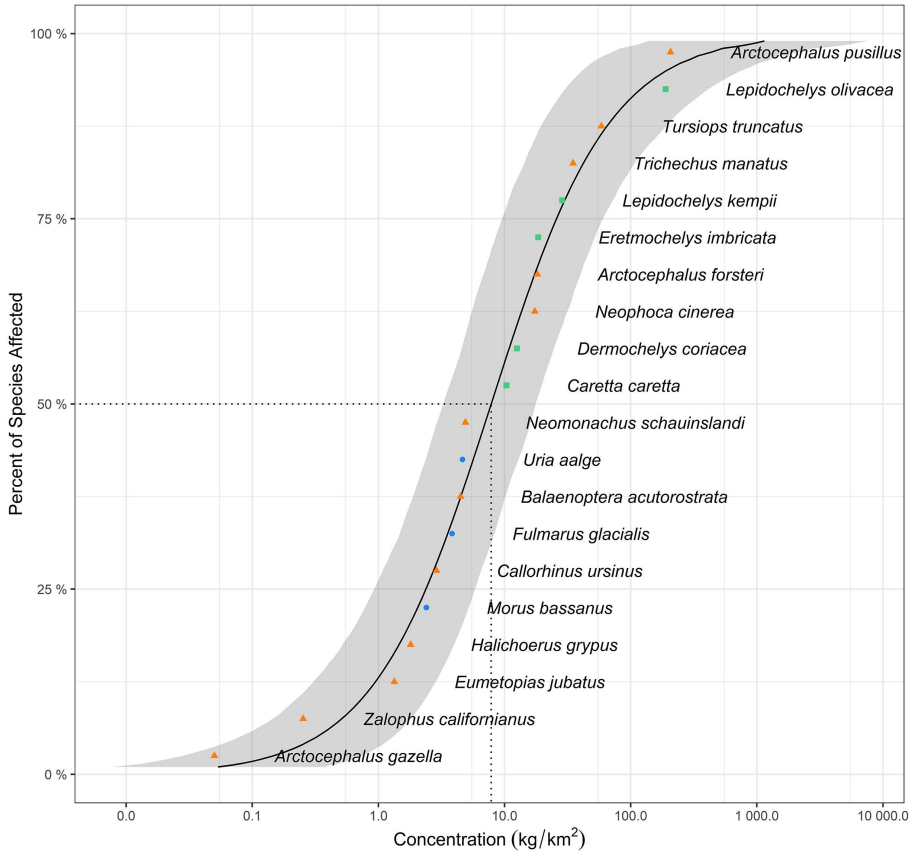
Data for estimated fishing effort from [globalfishingwatch.org](http://globalfishingwatch.org)

# ENTANGLEMENT RATES FROM THE FIELD AS SSD INPUT



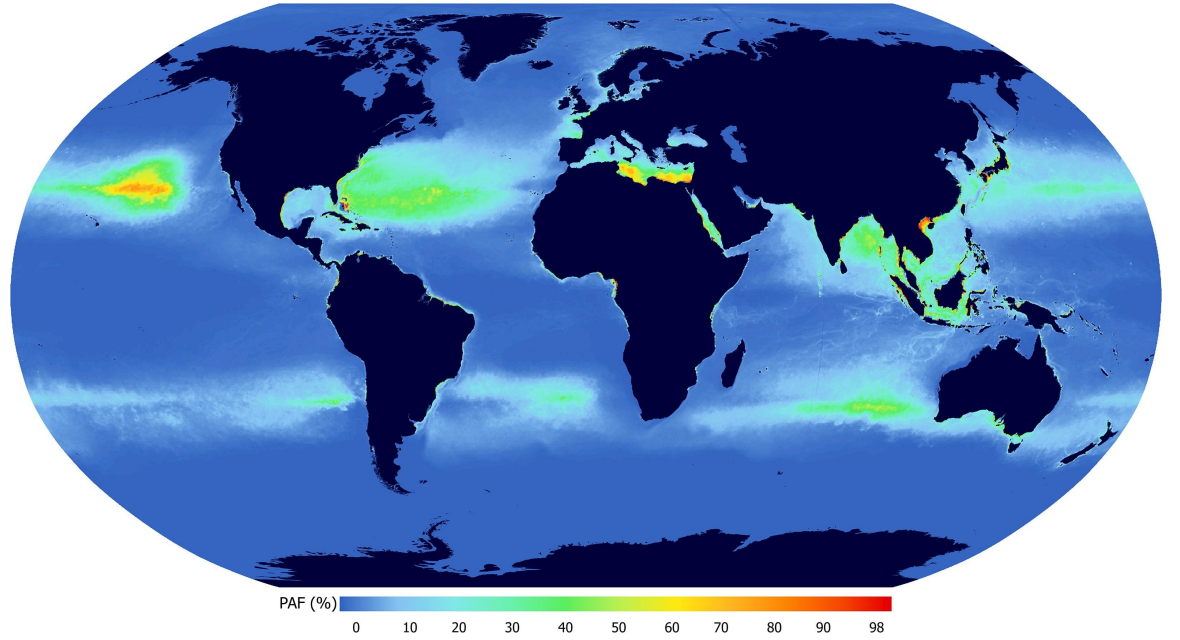
Locations of studies where entanglement rates were gathered from  
See Høiberg et al. (2022) for reference to studies and locations

# ENTANGLEMENT EFFECT MODEL



Species Sensitivity Distribution (SSD) curve

Plastic debris concentration dataset from Eriksen et al. 2014



Global Effect Factor: 
$$EF = \frac{0.5}{HC50} = 6.4E-08 \text{ PAF/kg.m}^{-2}$$

- Lower estimate: 2.1E-08

- Higher estimate: 1.9E-07



# Requirements for application

**INVENTORY**

→ Quantity, location, product and polymer type

**PRE-FATE**

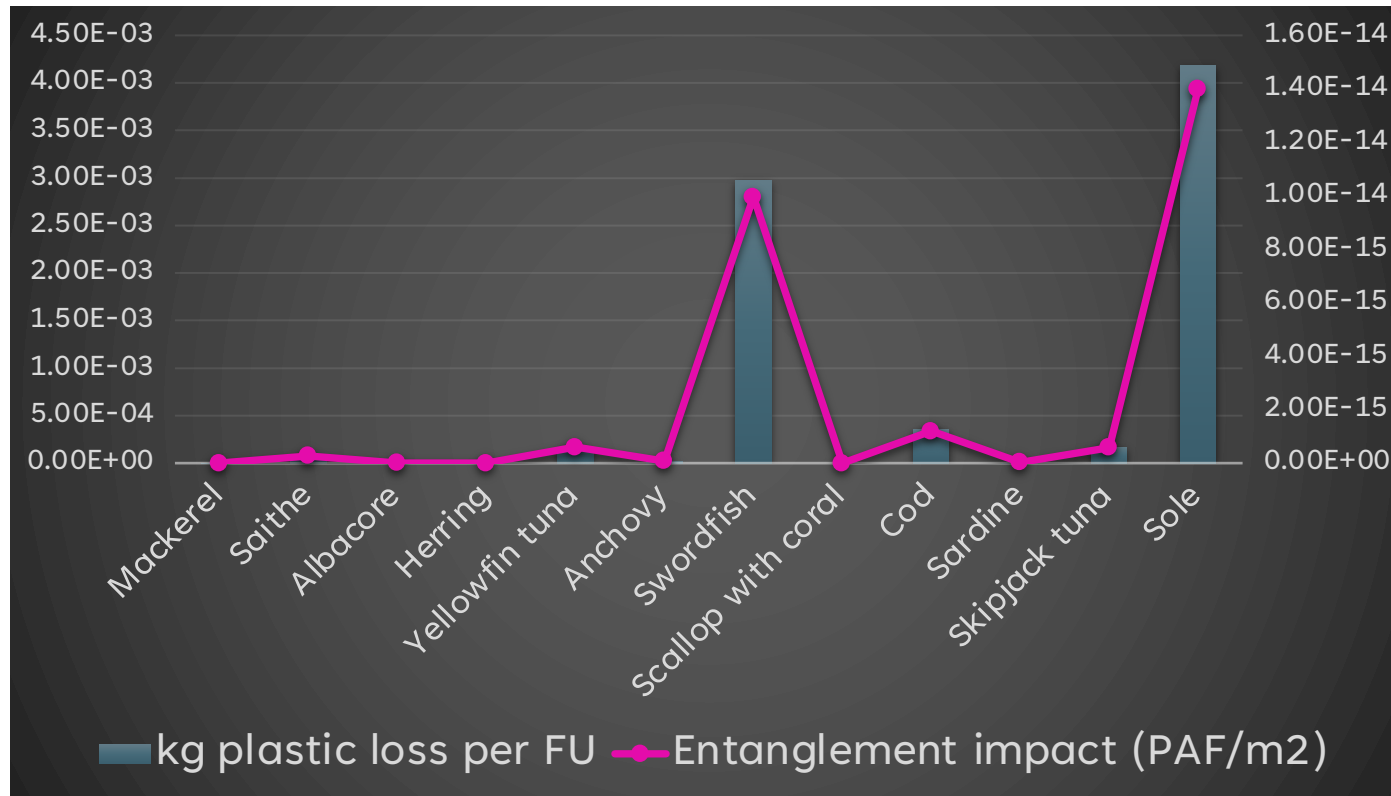
→ Mismanagement/loss rates, compartment transfer rates





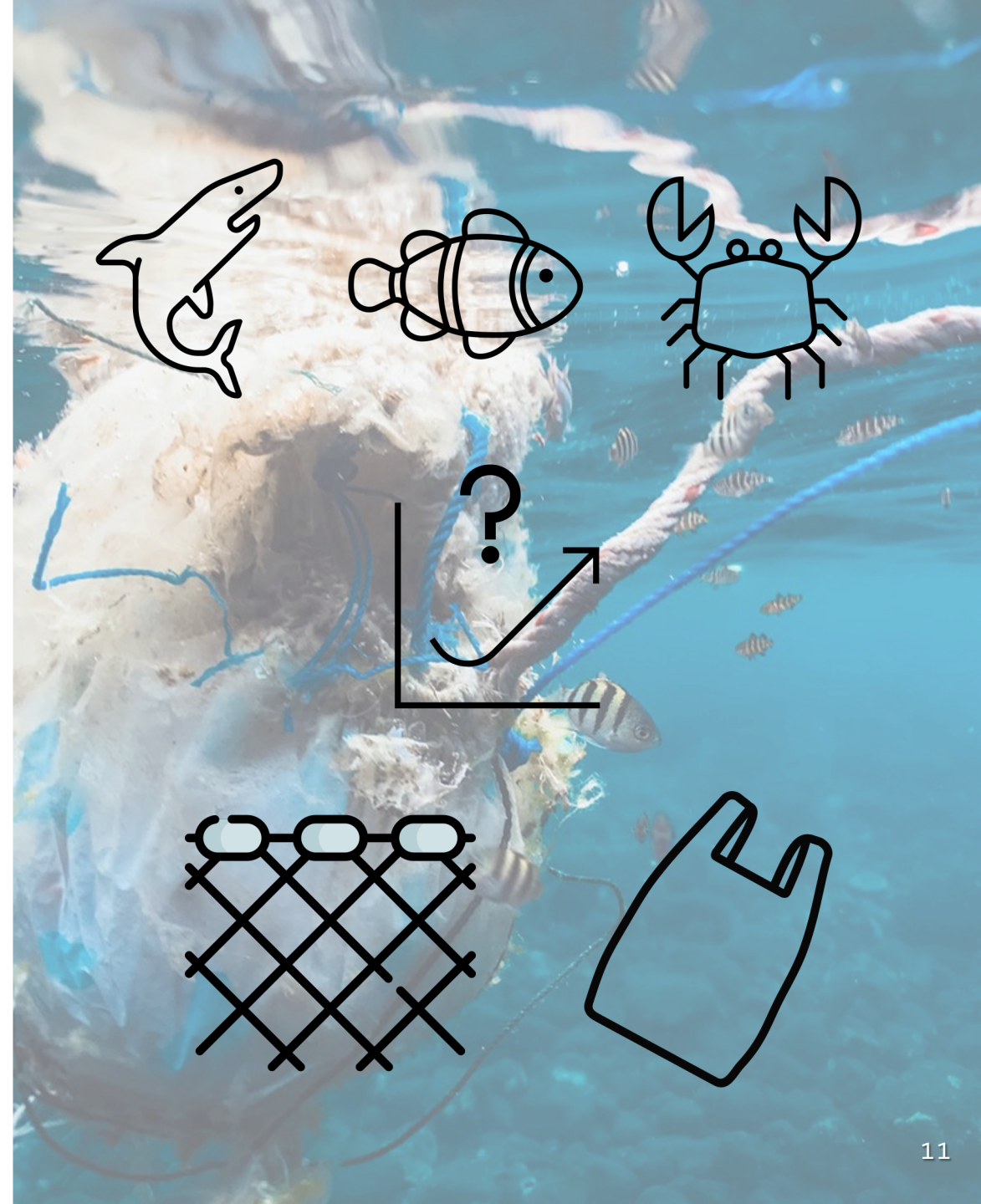
## EXAMPLE: FISH FROM FRANCE – LOUBET ET AL. 2022

- Potential entanglement impacts of 1 kg seafood fished in France
- Modelled release from top ten fishing effort points within French EEZ



## Caveats and further outlook

- Lack of ecosystem representation and standardized reporting
- Relationship between concentration and response
- Plastic item specificity in fate and effect





## References

- Eriksen, M., Lebreton, L.C.M., Carson, H.S., Thiel, M., Moore, C.J., Borrorro, J.C., Galgani, F., Ryan, P.G., Reisser, J., Dam, H.G. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea. PLoS ONE 9(12): e111913
- Høiberg, M. A., Woods, J. S., Veronesi, F. (2022) Global distribution of potential impact hotspots for marine plastic debris entanglement. Ecological Indicators 135:108509
- Loubet, P., Couturier, J., Horta Arduin, R., & Sonnemann, G. (2022) Life cycle inventory of plastics losses from seafood supply chains: methodology and application to French fish products. Sci Total Environ 804:150117.

**THANK YOU FOR LISTENING. QUESTIONS?**

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